

IN THE SPECIFICATION:

On page 1, in the paragraph beginning at line 6, please make the following changes:

Technical Field

The present invention relates to a low power radio frequency ~~radio or radar~~ device that is either a receiver that responds to an incoming radio frequency ~~radio or radar~~ interrogation signal by providing an output signal or a transmitter that provides an outgoing radio frequency ~~radio or radar~~ signal in response to an input signal, or a combination of both a receiver and a transmitter.

On page 1 in the paragraph beginning at line 12, please make the following changes:

Background of the invention

A device of this type would include a radio frequency ~~radio or radar~~ transponder. Such a device transmits a reply signal upon reception of an incoming signal. It usually includes a receiver, responsive to the incoming signal, for providing an amplified intermediate signal and a transmitter, responsive to the amplified intermediate signal, for transmitting the reply signal.

On page 1 in the paragraph beginning at line 17, please make the following changes:

For instance, present day radio frequency transponders are used to identify objects, possibly along with the contents thereof and even the location. An interrogator is used to send a radio frequency ~~radio or radar~~ signal to the transponder, where the transponder will reply back, potentially with information, also with a radio frequency ~~radio or radar~~ signal. Such transponders can be self-powered, enabling them to be mobile. Transponders are usually required to work at ranges that make it impractical to provide power by means of a radiated electric or magnetic field. The power supplies that are used to power the transponders are limited, meaning they contain or are able to supply only a limited amount of energy. Typically batteries are used but other sources could be used such as capacitors charged by solar or mechanical means, pressurized or flammable gas, etc. The consumption rate is proportional to the amount of time the transponder is powered to be operational.

On page 2 in the paragraph beginning at line 28, please make the following changes:

Therefore the only way to reduce the power consumption of the transponder is to increase its operating efficiency, and a need exists to significantly increase the operating efficiency of a receive section in a transponder. An increase in the operating efficiency of a transmit section in a transponder would also be beneficial. Such an advance could benefit radio frequency ~~radio or radar~~ circuitry in general and could be applied to any kind of radio frequency ~~radio or radar~~ circuitry including receiver, transmitters, and various signal-processing stages. Transponders have in the past used amplifiers in both the receiver and transmitter sections thereof. These amplifiers can consume most of the power needed to operate the unit.

On page 4 in the paragraph beginning at line 26, please make the following changes:

The above-mentioned importance of running radio frequency ~~radio or radar~~ devices with increased efficiency is particularly important for portable devices. If a constantly powered synchronous oscillator were to be used in a portable radar or radio device with a limited power supply such as a battery, the limited power supply would run down rather quickly. For instance, two AA batteries in series (3 volts) only have approximately 170 milliAmpere-Hours of total energy available for a load such as an S.O. (e.g., 1 mA load) and will therefore last only for a week or so. Nonetheless, it would be desirable that the device e.g. a receiver be able to operate with batteries that are widely available, such as AA size alkaline types and have the batteries last at least for a six month period in a receive mode. It would also be desirable to have the receiver work continuously or be available often and very quickly. Such a receiver should be sensitive enough to receive an interrogator signal transmitted from an interrogator transmitter at a selected power, e.g., 1 milliwatt at a selected distance, e.g., of up to 150 meters at a frequency of around 950 MHz, for instance. In such an example, the transmit path length and interrogator power level will require the receiver sensitivity to be about -80 decibels below the 1 milliwatt power level because approximately that amount of power is lost in the path length alone (assuming the transmit signal from the interrogator is dissipated in all directions at once). For a robust receiver design it is desirable to have excess sensitivity, high availability, and minimized power consumption. Higher receiver gain will of course consume a proportionately higher amount of power.

On page 5 in the paragraph beginning at line 8, please make the following changes:

Disclosure of Invention.

An object of the invention is to provide a portable ~~radar or radio~~ radio frequency device with improved power efficiency. This will allow the power source to last for a longer period of time for a given sensitivity. This can also allow the power source to become smaller.

On page 5 in the paragraph beginning at line 12, please make the following changes:

Another object of the invention is to allow a higher sensitivity receiver for a given amount of power consumption in a radio frequency ~~radio or radar~~ device.

On page 5 in the paragraph beginning at line 14, please make the following changes:

Yet another object of the invention is to reduce the parts complexity required to build an adaptable multi-function radio frequency ~~radio or radar~~ frequency signal processing stage with the benefits of increased reliability and reduced cost.

On page 5 in the paragraph beginning at line 17, please make the following changes:

Still another object of the invention is to provide a low power signal processing stage that can be configured for many purposes and perform different functions for use in radio frequency ~~radio or radar~~ circuitry.

On page 5 in the paragraph beginning at line 20, please make the following changes:

According to a first aspect of the invention, a radio frequency ~~radio or radar~~ device comprises an oscillator coupled to an application and to an antenna for providing an output signal in response to an input signal. Such a device may comprise a portable radio frequency ~~radio or radar~~ device having a limited power supply. In that case, according to the present invention, the device further comprises a power control for controlling power provided to the device during a limited period so as to consume a correspondingly limited amount of power from the power supply. The portable device then comprises the oscillator powered by the power supply during such a limited period, the oscillator coupled to the application and to the antenna, the device for providing the output signal for carrying out the application during the limited period in response to the input signal received by the device and amplified by the oscillator during the limited period.

On page 5 in the paragraph beginning at line 30, please make the following changes:

In further accord with the first aspect of the present invention, the antenna is for capturing an incoming radio frequency ~~radio or radar~~ input signal for providing a captured signal coupled to the oscillator via a first part of the application and wherein the oscillator is responsive to the captured signal coupled thereto for providing an intermediate signal to a second part of the application for providing the output signal. The first part of an application may be an electrical node and the captured signal provided directly to the oscillator without conditioning by any prior application part. On the other hand, in another application, the first part of the application may condition the captured signal for providing a conditioned signal to the oscillator. In that case, the oscillator further conditions the conditioned signal for providing the intermediate signal as a further conditioned signal to the second part of the application. The second part of the application may also condition the intermediate signal from the oscillator. But the second part of the application could instead merely be an electrical node and the intermediate signal provided from the oscillator is then same as the output signal from the second part of the application.

On page 6 in the paragraph beginning at line 19, please make the following changes:

Still further in accord with the first aspect of the present invention, a first application part of the application is responsive to the input signal for providing a conditioned signal, wherein the oscillator is responsive to the conditioned signal for providing an intermediate signal, wherein a second part of the application is responsive to the intermediate signal for coupling the intermediate signal to the antenna for providing an outgoing radio frequency ~~radio or radar~~ signal. The second part of the application may be an electrical node and the intermediate signal from the oscillator may then be provided directly to the antenna without conditioning by the second part of the application. On the other hand, the second part of the application may condition the intermediate signal for providing a conditioned signal to the antenna which in turn provides the outgoing radio frequency ~~radio or radar~~ signal for transmission. If the first part of the application is merely an electrical node, the conditioned signal from the first part of the application is therefore the same as the input signal and it is provided directly to the oscillator without any conditioning by the first part of the application. The first part of the application may instead condition the input signal for providing a conditioned signal to the oscillator. The first part of the application may also originate the conditioned signal provided to the oscillator. The oscillator may include means for heterodyning two or more signals. At least one of the two or more signals may be externally injected and the means for heterodyning may include means for heterodyning the at least one of the two or more signals with a signal provided locally to one or more oscillators.

On page 7 in the paragraph beginning at line 13, please make the following changes:

According to a second aspect of the present invention, a transponder comprises a first antenna responsive to an incoming radio frequency ~~radio or radar~~ signal for providing a captured radio frequency ~~radio or radar~~ signal, a first application part responsive to the captured signal, for providing a first coupled signal, an oscillator, responsive to the first coupled signal, for providing a conditioned output signal, a second application part responsive to the conditioned output signal, for providing a second coupled signal, and a second antenna, responsive to the second coupled signal, for providing an outgoing radio frequency ~~radio or radar~~ signal. The transponder may use a shared antenna instead of using the first and second antennas as separate antennas. The transponder may be configured as a ranging device.

On page 7 in the paragraph beginning at line 22, please make the following changes:

According to a third aspect of the present invention, a device comprising a quadrature hybrid for providing a pair of quadrature signals in response to an input signal, a pair of oscillators each responsive to a respective one of the quadrature signals for providing oscillator output signals, and a summer, responsive to the output signals from the oscillators, for providing a summed output signal. The device may further comprise a power control for controlling power provided from a power supply to the device to a limited period. The device may further comprise at least one antenna coupled to the device. The device may be a portable radio frequency ~~radio or radar~~ device. The device may further comprise a power control for controlling power provided from a power supply to the device to a limited period.

On page 12 in the paragraph beginning at line 3, please make the following changes:

Fig. 1 shows a radio frequency ~~radio or radar~~ device, according to the present invention, comprising an application 1cd coupled to an antenna 1a and to an oscillator which is preferably but not necessarily a synchronous oscillator (S.O.) 1b. The antenna and the S.O. work together with the application 1cd to carry out the ends of the application which can be various. According to the present invention, the application takes advantage of the signal processing properties of the S.O. The application 1cd is shown comprising two parts, one part 1c coupled between the antenna 1a and the S.O. and the other part 1d coupled to the S.O. on the other side of the S.O., but it should be realized that the application may comprise one or both parts 1c, 1d. Either or both application parts 1c, 1d can exist in a given embodiment and their functions can be separate or overlapping but nonetheless together constitute an application. The application therefore interfaces with an input, an output, or both the input and the output of the S.O. If the application part 1c is interfaced with the input to an S.O. 1b, then the application part 1d interfaces with the output of an S.O. 1b. In a similar fashion, if the application part 1c is interfaced with the output of an S.O. 1b then the application part 1d interfaces to the input of the S.O. 1b. As shown below, signals can be received, transmitted, or both by the synchronous oscillator in these configurations.

On page 12 in the paragraph beginning at line 18, please make the following changes:

For instance, the radio frequency ~~radio or radar~~ device of Fig. 1 may be used as shown in Fig. 2 as a receiver. In that case, an incoming radio frequency ~~radio or radar~~ signal 2 transmitted e.g. by an interrogator (not shown) in air or free space is captured by an antenna 2a which is responsive to the incoming signal and a captured signal is provided on a line 2ac. The signal on the line 2ac may be injected into an application part 2c. In that case, the application part 2c can perform signal processing on the signal on the line 2ac before outputting the conditioned signal on a line 2cb to an S.O. 2b. The application part 2c can originate signals that are injected into S.O. 2b by the signal on the line 2cb along with the signal that was supplied from the line 2ac. If the connection between the line 2ac and the line 2cb is direct, the application part 2c is nothing more than an electrical node and the signal on the line 2ac and the line 2cb is the same. The S.O. 2b performs signal processing on the input signal(s) on the line 2cb and outputs a conditioned, intermediate signal on a line 2bd to application part 2d. The application part 2d uses the conditioned, intermediate signal from the line 2bd to perform the remaining function of the application. The application part 2d performs signal processing on the intermediate signal on the line 2bd and uses the processed signal for the function of the application. If required for a specific application, an output signal from the application part 2d is made available on a line 2e. If the application part 2d simply contains an electrical node between lines 2bd and 2e, the signal out of the application part 2d on the line 2e is the same as the signal on the line 2bd output from the S.O. 2b on the line 2bd.

On page 12 in the paragraph beginning at line 36, please make the following changes:

The device of Fig. 1 may take the form of a portable radio frequency radio or radar device having a limited power supply 1f such as a battery. In such a device, according to the present invention, power is provided to the synchronous oscillator during a limited period so as to consume a correspondingly limited amount of power from the limited power supply. The illustrated limited power supply 1f may be connected to either the S.O., the application or to a combination 1g of both the S.O. and the application, under the control of a power controller 1h that controls the on-off position of a switch 1k connecting the limited power supply to the combination 1g of the application 1cd and the S.O. 1b. The limited power supply 1f might for instance be a battery and the power control controlling the switch to only periodically apply power from the battery to the S.O. 1b, to the application 1cd, or both. In such a case, the power control of Fig. 1 may be used to cause the limited power supply or battery to supply power to the S.O. 1b for 10ms every 5 seconds. This gives a duty cycle of 500 to 1. Such a duty cycle would increase the battery life by 500 to 1 over continuous power consumption. That would make two AA batteries last for years instead of days.

On page 13 in the paragraph beginning at line 12, please make the following changes:

Consequently, the device of Fig. 1 taking the form of a portable radio frequency radio or radar device may have a power supply and a power control for controlling power provided to the device during a limited period so as to consume a correspondingly limited amount of power from the power supply. Such a portable device comprises the synchronous oscillator (1b) powered by the power supply during the limited period, the synchronous oscillator coupled to the application (1cd; 1c; 1d) and to the antenna (1a), the device for providing the output signal (2e; 3) for carrying out the application during or only during the limited period in response to the input signal (2; 3e) received by the device and amplified by the synchronous oscillator during the limited period.

On page 13 in the paragraph beginning at line 20, please make the following changes:

Likewise, the device of Fig. 2 may take the form of a portable radio frequency radio-or radar-device having a limited power supply 2f such as a battery. In such a device, according to the present invention, power is provided to the synchronous oscillator via a switch 2k during a limited period so as to consume a correspondingly limited amount of power from the limited power supply. The switch is controlled open or closed by a control 2h. Gain is imparted to the input signal by the synchronous oscillator during such a limited period (if an input signal is present). A correspondingly limited amount of power is consumed from the limited power supply. If and when a sending device (e.g., interrogator) is present and it sends an interrogation signal, if the duration of the interrogation (input) signal is controlled by the sending device so as to provide a discontinuous interrogation signal in the form of a pulse, burst or the like (that only lasts for a limited period and may not present at other times), then the period of the interrogation pulse can be set up so as to extend longer in time than the time between applications of power to the SO in the receiver. In that way, an overlap in the timing of the power-up of the SO and the pulse is ensured without needing any timing control between the sending device and the receiver. For instance, if the sending device sends a continuous interrogation signal for 5 seconds, the receiver can be set up to turn on for 10 ms every 5 seconds and it will definitely receive at its input any interrogation signal sent by the sending device.

On page 14 in the paragraph beginning at line 1, please make the following changes:

Fig. 3 shows an outgoing radio frequency radio-or radar-signal 3 transmitted in air or free space by an antenna 3a connected to a synchronous oscillator 3b via an application 3cd which may comprise one or both application parts 3c, 3d. An application part 3c injects a conditional signal or a plurality of conditional signals into S.O. 3b on a signal line 3cb. Signals can be injected into application part 3c on a line 3e. The application part 3c can perform signal processing on the signal on the line 3e as well as generate signals internally before outputting a conditioned signal on the line 3cb. The S.O. processes the signal(s) and provides an intermediate signal output on a line 3bd to the application part 3d. The application part 3d can perform signal processing on the signal on the line 3bd as well as generate signals before outputting a conditioned signal on the line 3da. If the connection between the line 3bd and the line 3da is direct, the application part 3d is nothing more than an electrical node and the signal on the line 3bd and the line 3da is the same. The output signal of the application part 3d on the line 3da is injected into an antenna 3a for transmission. The antenna 3a in turn provides the outgoing radio frequency radio-or radar signal on the line 3.

On page 14 in the paragraph beginning at line 14, please make the following changes:

Like the devices of Figs. 1 and 2, the device of Fig. 3 may take the form of a portable radio frequency radio or radar device having a limited power supply 3f such as a battery. In such a device, according to the present invention, power is provided via a switch 3k under the control of a power controller 3h to the synchronous oscillator during a limited period so as to consume a correspondingly limited amount of power from the limited power supply. Gain will be imparted to any input signal 3cb that happens to be present by the synchronous oscillator 3b during or only during the limited period of availability of the power supply.

On page 19 in the paragraph beginning at line 11, please make the following changes:

It will therefore be realized that the radio frequency radio or radar device of the present invention can be configured as a receiver or a transmitter, in either case taking advantage of the properties of the synchronous oscillator 2b or 3b, to be described below in more detail. But first a device combining both a receiver and transmitter, each according to the present invention, will be shown.

On page 19 in the paragraph beginning at line 15, please make the following changes:

Fig. 12 shows a radio, or radar transponder 10 that transmits a radio frequency radio or radar reply signal 12 upon reception of an incoming radio frequency radio or radar signal 14. A transponder is a receiver/transmitter pair. The receiver configured according to Fig. 2 is converted to a transponder by the addition of a transmit antenna on the line 2e. Likewise, the transmitter configured according to Fig. 3 is converted to a transponder by the addition of a receive antenna on the line 3e. The transponder 10, shown in greater detail in FIG. 12(a), comprises a receiver 16, configured according to Fig. 2, responsive to the incoming (input) signal on the line 14 for providing a receiver output signal on a line 28bd by means of one or more synchronous oscillators 22, 24, ...26 within the S.O. block 2b. The transponder can reply at the same frequency that is transmitted to it. Signal processing either in the S.O. stages or the attached application parts can create a different reply frequency.

On page 20 in the paragraph beginning at line 3, please make the following changes:

The receiver 16 of Fig. 12(a) may receive the incoming signal 14 from an antenna 28a in the case of an incoming radio frequency ~~radio or radar~~ signal. The antenna 28a provides the incoming signal as a signal on a line 28ac to a first application part 28c of the receiver 16. The first application part 28c provides a coupled signal on a line 28cb to the S.O. 2b. The antenna 28a, the first application part 28c, and the S.O. 2b of Fig. 12(a) should be viewed as an example of the device of Fig. 2 wherein the antenna 28a may be connected directly to the synchronous oscillator. In that case, the first application part 28c is simply an electrical node and the signals on lines 28ac and 28cb are the same.

On page 20 in the paragraph beginning at line 18, please make the following changes:

The transponder 10 also includes a transmitter (like that of Fig. 3) including the S.O. 2b, 3b, a third application part 28d, and an antenna 30a. In the radio frequency ~~radio or radar~~ case of Fig. 12(a), the third application part 28d will provide a signal on a line 28da to the antenna 30a which in turn provides the reply signal on the line 12. The signals on the lines 14 and 12 are, of course, radio frequency ~~radio or radar~~ signals propagating in the air or free space. In some cases, it may be desirable to utilize an in-line switch as the third application part 28d that is only closed when an input signal is being received and amplified by the S.O. 2b, 3b. This will suppress any radiation of the oscillations occurring in the tank circuit of the S.O. 2b, 3b when the S.O. is being periodically powered-on despite the absence of an input interrogation signal. This may be accomplished by having a switch control sensing for the presence of an input signal and closing the switch to connect the S.O. output to the antenna 30a only upon sensing such an input signal received by the antenna 28a. If such a switch were not used, the signal radiated from the transmit antenna 30a would not be carrying out the purposes of the application. Such might or might not be harmful, depending on the circumstances, so the use of such a switch is a design choice.

On page 27 in the paragraph beginning at line 24, please make the following changes:

A radio frequency tag is a device that is attached to something to identify, classify, or label it. The tag information is conveyed to an interrogator unit by wireless radio frequency means. The transponder of Fig. 12, can be applied as a radio frequency tag, and will now be described in detail in connection with Fig.12 (a), with three stages of synchronous amplifiers 22, 24, 26 acting in different modes. Although the transponder can be configured with more or less stages, an example will be useful to show different uses for the synchronous amplifier stages. The stages in the transponder can be compared to the stages in a conventional radio receiver because the signals in the stages of a conventional radio receiver are similar to signals in the stages of a transponder. A conventional radio receiver that produces an audible output contains radio frequency stages that have specific functions. An example of a common radio receiver contains four different stages to receive a radio signal and produce an audio output. The function of the first stage is to amplify the receive signal captured from an antenna. The function of the second stage is radio tuning with a local oscillator and a heterodyne mixer circuit. The second stage frequency translates the amplified receive signal from stage one to a specific frequency that a third stage operates at. The function of the third stage is to filter undesired signals and is optimized to work at a specific frequency that is output from the second stage. The function of the fourth stage is to detect the audio signal present on the frequency converted and filtered radio frequency signal and produce an audible output. The transponder described does not produce an audio output so a stage performing the function of the fourth stage as described above is not required. The filtered frequency output from the third stage described above will be used as the transmit signal in the transponder. In the transponder, S.O. stage 22 will be used as the first stage and will function as an amplifier for the received signals captured from the receive antenna. Fig. 13 shows the S.O. 22 in detail. This is similar to the first stage 22 shown in Fig.21 which is shown to be an amplifier for the frequency F1. S.O. stage 24 of Figs. 12(a), 16, and 21 will be used as the second stage which will frequency translate the signal from stage one to a desired transponder transmit frequency via the use of a local oscillator and heterodyning mixer. S.O. 22 as shown in Fig. 13 has one input 18. In order to heterodyne two or more signals by an S.O. stage, it is required to inject the two or more signals into the stage. If one of the mixing signals is generated locally in the S.O. stage, the other heterodyne mix signal is injected on the input to the S.O. stage requiring only one input. The signal generated locally and the signal externally injected would heterodyne and produce mixing products on the output of the S.O. stage. If no signals are generated locally to the S.O. stage, the signals that are to be heterodyned are injected externally to the S.O. stage as shown in Fig. 16 requiring an input for each different signal. This will require the S.O. stage to have available more than one input to accommodate the different injected signals. Fig. 16 shows the additional input and a resonant network 50 of S.O. 24 as compared to

S.O. 22 of Fig. 13. The S.O. 24 is a modified version of S.O. 22 adding inputs 80,81 to make the S.O. 24 more flexible in use for inputting signals used for modulation and frequency conversion. S.O. stage 24 also has the capability of generating a signal locally through the use of a resonant network 50. This stage is similar in operation to the stage 24 shown in Fig. 21. By using a crystal resonator 50 in the feedback path (such as in Figs. 16 and 18) on the input transistor Q2, the output will contain $F1$, the mix frequencies $F1 + F_{xtal}$ and $F1 - F_{xtal}$. The LC network L-C2-C3 will still be tuned to $F1$. The resonator in S.O. 24 can be implemented with other devices besides a quartz crystal, as suggested by Fig. 19. A simple L-C network can be used as the resonator. Electrically tunable elements can be incorporated for the purpose of modulation which is not used in this example. S.O. stage 26 will be used as the third transponder stage and will filter any undesired signals from the second stage, S.O. 24, and output the filtered signal to the transmit antenna. S.O. 26 has the same structure as S.O. 22 of Fig.13. As shown in Fig. 21, to filter the unwanted frequency components the final output stage 26 will be used as a single sideband filter by tuning the LC network L-C2-C3 to $F1 + F_{xtal}$. Referring back to Fig. 12(a), the transponder is built by taking the configuration of Fig. 21 and adding antennas 28a, 30a and applications 28c,28d (either or one of which could be a mere node). The transponder will track input frequency $F1$ captured by antenna 28a and will reply on the line 28bd and on the line 28da with $F1 + F_{xtal}$. The signal on line 28da is injected into the transmit antenna 30a. The antenna 30a in turn provides the outgoing radio frequency ~~radio or radar~~ signal on the line 12. If the transponder application required modulation to be introduced, this would be possible through the use of application 34e on a line 34eb. Placement of a modulator in the transponder radio frequency chain is dependent on several factors. One factor is the type of modulation and another is its bandwidth. The transponder can be made to reply with Amplitude modulated (AM), FM, PM or spread spectrum signals.